Evaluation of S4S Solar grain dryer for drying paddy seeds

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Abstract: Proper drying is needed for producing quality paddy seed. Open sun drying is often produced seed with foreign materials. Solar dryer produced by science for society (S4S), India might be suitable for country like Bangladesh. Therefore, the dryer was evaluated with six trials in *Boro* season 2017 and with three trials in *Aman* season, 2017 at Bangladesh Agricultural University, Mymensingh, Bangladesh. Paddy seed samples were also dried by open sun drying in *Aman* season to compare the performance of the dryer. Depending on paddy variety the capacity of the dryer was 42.4 to 55.0 kg batch^{-1}. Dryer performance and seed quality were evaluated using standard formula and methods. Results revealed that temperature distribution at different locations inside the dryer was fluctuated within a narrow band. Drying time was 13.5 to 29 hours and 6.5 to 8 hours in *Boro* and *Aman* seasons, respectively depending on sufficient sunshine hours and initial moisture content of paddy whereas the drying time was within 7.5 to 8 hours in *Aman* season in case of sun drying. Drying rate was 0.67% to 0.7% MC hr^{-1}. The average drying loss measured in S4S solar grain dryer (0.41%±0.55%) was lower than sun drying (2.12%±1.24%) in *Aman* season. The germination and vigor index of S4S solar grain dryer dried paddy seeds were satisfactory ranged 82% to 97% and 1638 to 2232 compared to sun drying ranged 79% to 80% and 1738 to 1973, respectively. Thus, paddy seeds can be dried in S4S solar grain dryer without impairing germination and vigor of seed. Farmers can get better quality seed when using S4S solar grain dryer.

Keywords: solar drying, temperature, moisture content, drying loss, germination

Citation: Roy, D., Saha, C. K., Alam, M. A., Sarker, T. R., Alam, M. M. 2020. Evaluation of S4S Solar grain dryer for drying paddy seeds. Agricultural Engineering International: CIGR Journal, 22 (4):200-210.

1 Introduction

Paddy is the main cereal crop of Bangladesh and grown throughout the country except in the southeastern hilly areas in different growing seasons named- *Aus* (May to August), *Aman* (July to November) and *Boro* (January to May) and recently reported to account for 7%, 38% and 55%, respectively, of the total paddy production (Shelly et al., 2016). Drying of cereal grains is an essential processing technology that affects directly their quality, appearance, taste and production cost (Pirasteh et al., 2014). Delayed drying, incomplete drying and ineffective drying will reduce grain quality and also result in grain losses. Therefore, to prevent the deterioration and to increase the safe storage life of paddy, drying is an important postharvest operation. It permits the farmers to secure a greater economic return and ensure long term storage.

Major inputs for paddy production are seed, fertilizers, irrigation water and pesticides in where paddy seed quality is the essential element. In Bangladesh more than 50% of

Received date: 2020-01-13 **Accepted date:** 2020-04-10

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the farmers use seeds from their own harvest which are locally produced (Shelly et al., 2016). The government organization, Bangladesh Agricultural Development Corporation (BADC), contributes 13% (average of all crops) quality seeds, and in case of *Boro* rice seed supplies more than 60% (BADC, 2015). Moisture content in rough paddy influences quality of paddy during storage. The germination rate of seed reduces with high moisture content of grain. Therefore, it is important to reduce moisture content to 12% using an appropriate drying process.

Drying of paddy is usually done by two ways, one is open sun drying and other is mechanical drying by using different types of dryers (Ashfaq et al., 2016). In Bangladesh, open sun drying is a common and traditional practice for drying of paddy seeds. This method is labor intensive as well as degrades the quality of paddy. As temperature cannot be controlled, it causes non uniform drying of paddy seeds. There are different types of mechanical dryers (Batch dryer, Re-circulating dryer, Continuous flow dryer) for paddy drying which need electricity and biomass to produce heat (Mohapatra, 2012). Energy consumption is higher of these dryers. Therefore, it is important to develop such a dryer which deals with the high quality of the product at low energy consumption and uses natural resources. Many researchers have carried out studies on solar dryers for effectiveness in providing the quality products and are classified based on the mode of air circulation, like, natural circulation and forced circulation solar dryers; based on the type of drying, like, direct solar drying, indirect solar drying and mixed mode solar drying etc. In case of direct solar drying, direct exposure to solar radiation reduces the quality of products with low drying rate. Addressing this problem, indirect solar drying is the new and more effective technique of product drying (Phadke et al., 2015).

Science for Society (S4S) in collaboration with Bill and Melinda Gates Foundation, USA has developed a “Solar Grain Dryer” which may reduce the initial moisture content in grains from 28% to 30% up to 10% to 12% with proper hygienic condition, maximum nutrition retention and less labor. In country like Bangladesh, S4S solar grain dryer might be suitable method for drying paddy seed as an alternative to open sun drying and mechanical drying methods. Hence, it is important to test the S4S solar grain dryer vigorously before suggesting to the farmers of Bangladesh. The Specific objectives of this study were (i) to investigate spatial and temporal distribution of temperature and moisture at different locations inside of S4S solar grain dryer, (ii) to evaluate technical performance of S4S solar grain dryer for paddy seeds, and (iii) to evaluate the quality of seeds dried using S4S solar grain dryer.

2 Materials and methods

2.1 Experimental site

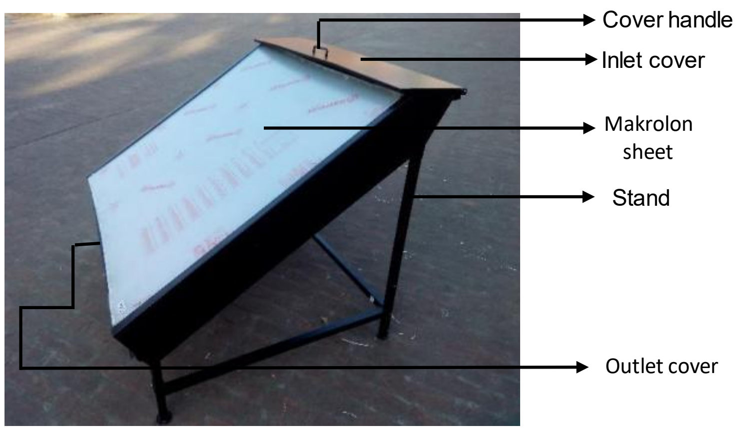
The experiment was conducted at the Workshop of the Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh, during the period of 2017.

2.2 Description of S4S solar grain dryer

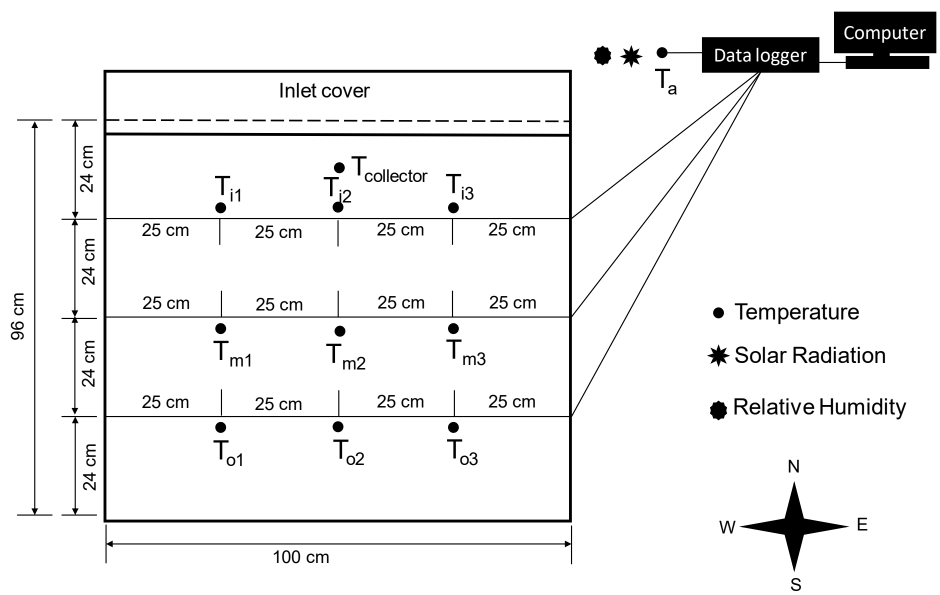
The S4S solar grain dryer is a solar based dryer and the unique feature of this technology is, it converts solar energy to heat energy and then pass the heated air through the drying chamber by natural convection. It is a closed system, thus prevents seed loss through birds, flies, dust and rains while drying. The dryer consists of solar collector (makrolon sheet with UV protected), aluminum based iron net, drying chamber, dryer stands, inlet and outlet section with covering (Figure 1a).

The length and width of the collector is same, 101 cm and used for collecting solar energy. The thickness of makrolon sheet is 0.7 cm. The drying chamber is the place where paddy seeds are poured and drying operation takes place. The drying chamber has a dimension of 100×96 (Length × Width) cm. The thickness of the drying chamber is 10 cm and entire part of the chamber is equally divided into 18 sections and all over the chamber it is perforated with small round shape. A plain net with aluminum structure is used as a base structure of drying unit and the drying chamber is placed on it. The dimension of the net is

101×101 (Length × Width) cm; whereas openings of net are square in shape and the mesh size of the net is 8×8. The inlet and outlet cover is made of galvanized sheet and dimension is 102×24 (Length × Width) cm and 95×12.5 (Length × Width) cm. The frame of the dryer was installed by adjusting the stands horizontally with fixed type vertical stands by fixing nuts and bolts properly, which accomplished to give 60^0 inclined rectangular shape of the dryer. Then a square shaped plain net with aluminum structure was placed on the inclined structure and fixed with four nuts and bolts. After that a perforated structure was placed on the net which has several sections and performed as a drying unit. A makrolon sheet of UV protected which served as a solar collector was placed on the top of drying unit. Finally, inlet and outlet covers were set at the inlet and outlet section of the dryer.



(a) Pictorial view of the dryer



(b) Experimental layout of the dryer in *Boro* and *Aman* seasons (T-temperature sensor, i-inlet, m-middle, o-outlet, a-air)

Figure 1 S4S solar grain dryer

2.3 Experimental set-up and procedure of dryer test

The S4S dryer was set in N-S orientation. Ten k-type thermocouples were set up at different locations to get the temperature reading in real time (Figure 1b). One thermocouple was placed outside of the dryer for recording the ambient temperature and eight thermocouples were placed inside the grain at different points of the drying unit to record the grain temperature named paddy space temperature. All temperature sensors were placed from west side to east and 25 cm apart from each other according to experimental position of the dryer. One was placed between the gap of the drying unit and the solar collector at the inlet side of the dryer to record how much heat was trapped by the solar collector except Trial 1 and Trial 2 in *Boro* season which was mentioned as head space temperature. The thermocouples were connected with a fluke type data logger (FLUKE 2635A Hydra series, ±0.018%, U.S.A) connected with a computer during the operation and the grain surface temperature was recorded every 10 seconds interval. In *Aman* season, the experimental layout was same except the number of thermocouples. In this season, two thermocouples were used at east and west corners in inlet and outlet side and three were used in middle position of the dryer.

Paddy was collected from BAU farm and weighed by a digital balance before pouring paddy samples. The experiments were carried out with six trials in *Boro* season named Trial 1, Trial 2 and Trial 3 using paddy variety BRRI dhan50 and Trial 4, Trial 5 and Trial 6 using paddy variety BRRI dhan29. In *Aman* season, the dryer performance was also evaluated with three trials named Trial 1, Trial 2 and Trial 3 using paddy variety BINA dhan7 and compared with sun drying. In each trial, the weighed paddy samples were poured into the drying chamber in such a way that all the sections of the chamber contained equal amount of paddy. The thickness of the drying bed was maintained 10 cm. The initial moisture content of paddy, weight of paddy, ambient temperature, relative humidity and solar radiation were recorded before the drying operation.

Closing the inlet and outlet covers, drying operation was started. The TRH1000 data logger (Temperature: ±2.0°C from -40°C to 70°C and RH: 4% RH between 20% and 80%) and sensor was also used for ambient temperature and relative humidity in every 5 minutes interval. The moisture content of paddy was measured manually every half an hour interval by using a digital moisture meter (Riceter-L, ±0.5%, Japan) after collection of paddy sample at three different locations by an auger from the drying unit. Solar radiation was also measured manually every half an hour interval by using a solarimeter (SL 100, ± 5% W m^{-2}). Seed samples were collected in polybags and weighed (500 g) after conducting each trial of the experiment and kept airtight to conduct the germination and vigor test, respectively.

2.4 Seed quality test

To accomplish germination test, healthy and pure seeds were selected by visual method. Dry sands free from debris, hard metal and other foreign materials, were collected and then sieved for removing any kind of stone from sands. After that, the sand medium was soaked with water to create favorable condition for seedling raising. The counted seed samples were placed uniformly on moist sand container. A little amount of dry sands spread over the seeds for germination of seeds. The test was conducted for three replications of 100 seeds for each sample. Then, the containers were kept in a rack covered with iron net at room temperature for fourteen days. Water was sprayed over the containers for better germination. Seeds that have roots or shoot longer than 2 mm were considered as germinated seed (Hossain et al., 2012). After germination test, seed vigor index was determined by the following equation for seed quality test (Govindaraj et al., 2017).

$$\text{Vigor index} = \text{Germination, \%} \times \text{Total seedling length, cm} \quad (1)$$

2.5 Calculation of technical parameters

2.5.1 Moisture removed

The amount of moisture removed from the paddy was determined by the Equation 2 (Aktar, 2016).

$$M_w = \frac{M_p\left(M_i - M_f\right)}{\left(100 - M_f\right)} \quad (2)$$

Where, M_w is mass of water removed from wet paddy(kg); M_p is initial mass of paddy to be dried (kg); M_i is initial moisture content of paddy(wb); M_f is final moisture content of paddy(wb).

2.5.2 Drying rate

The drying rate of paddy sample during drying period was calculated using the Equation 3.

$$DR = \frac{\text{Percentage moisture content removed}}{\text{Time in hour}} \quad (3)$$

2.5.3 Drying efficiency

Drying efficiency was calculated by the following Equation 4 (Alam et al., 2016).

$$\eta = \frac{WL}{E_t} \tag{4}$$

Where, W is moisture evaporated(kg); L is latent heat of vaporization of water(MJ kg^{-1}); E_t is total energy consumption (MJ).

Total energy consumption can be calculated by using Equation 5 (Aktar, 2016).

$$E_t = \frac{R_s \times A \times t}{10^6} \tag{5}$$

Where, R_S is solar radiation (W m^{-2}); A is drying area of S4S solar grain dryer (m^2); t is time required for drying(s).

2.5.4 Drying loss measurement

Drying loss measurement, an important performance parameter which provides the information on how much paddy seeds were being losses at the time of drying paddy seeds. The following formula (Equation 6) was used to calculate drying losses of paddy (Nath et al., 2016).

$$\textit{Drying loss, \%} = \frac{D_{2i} - D_{2f}}{D_{2i}} \times 100 \tag{6}$$

$D_{2i} = D_{1i} \times MCF \times F_g$

$D_{2f} = D_{1f} \times MCF \times F_g$

Where, D_{1i} is initial weight of paddy at field moisture content(kg); D_{2i} is adjusted weight at 14% moisture content(kg); D_{1f} is weight of the paddy sample after drying(kg); D_{2f} is adjusted weight after drying at 14% moisture content(kg); F_g is % of filled grain. Moisture conversion factor was calculated using Equation 7 (Nath et al., 2016).

Moisture conversion factor,

$$MCF = \frac{100 - M_i}{86} \tag{7}$$

Where, M_i is initial moisture content

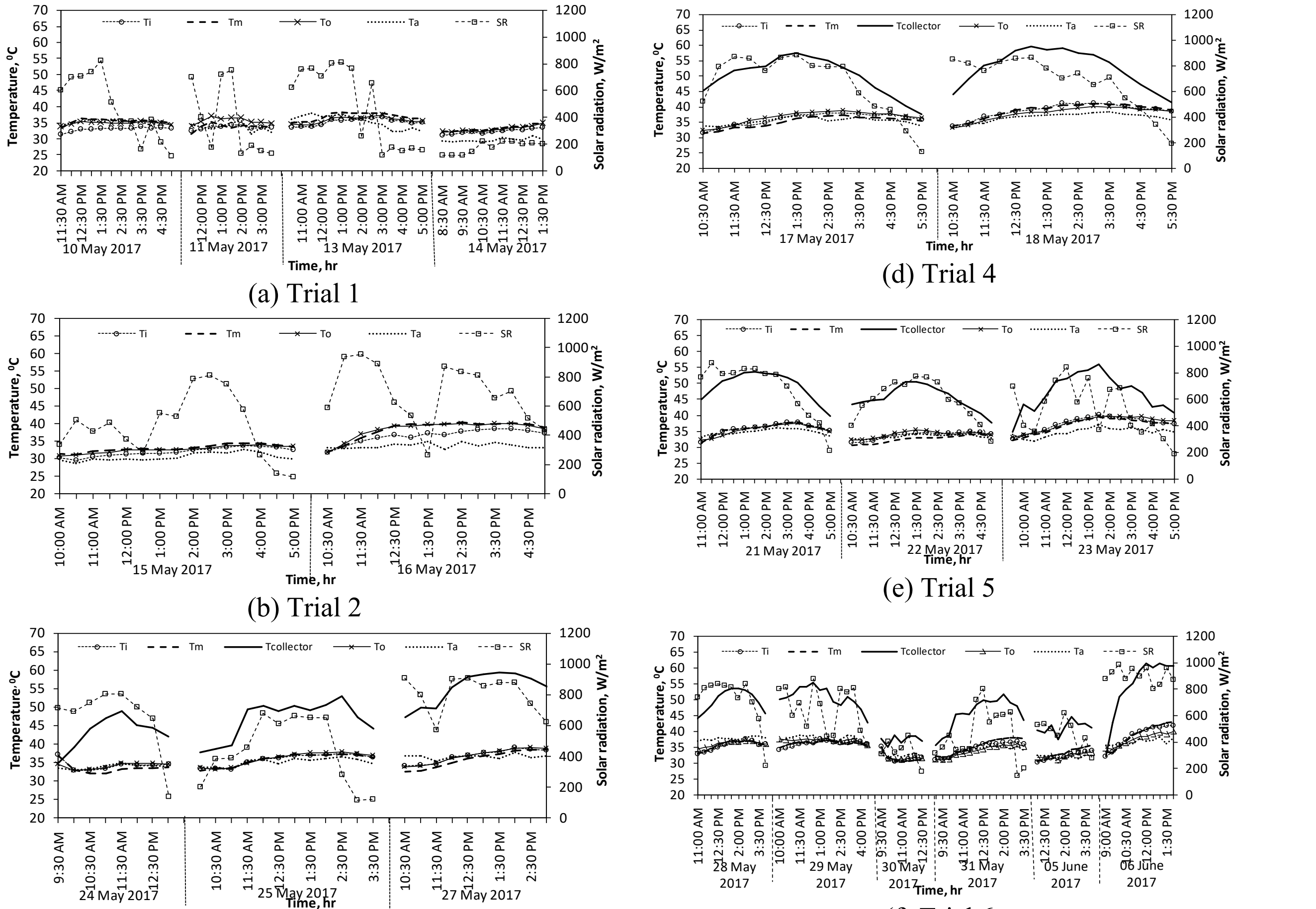
2.6 Comparison of S4S solar grain dryer with sun drying method

Open sun drying is a traditional method. The performance of S4S solar grain dryer was compared with open sun drying method to determine the better options for drying paddy seeds in this region. Same amount of paddy samples was spread on drying floor with 4 cm paddy thickness in open sunshine at the Workshop in every trial of S4S solar grain dryer during *Aman* season. Paddy seeds were pulverized every one-hour interval during drying operation in open sun drying method.

3 Results and discussion

3.1 Effect of solar radiation on temperature distribution inside and outside of S4S solar grain dryer in different seasons

In *Boro* season, temperature in and outside the S4S dryer was varied depending on solar radiation and time of the day. When solar radiation was increased, the ambient air temperature was also increased with respect to time (Figure 2). At the same time, with increase in solar radiation the head space temperature of the dryer i.e. collector temperature was increased. Paddy space air temperatures at all the points of the inlet, middle and outlet positions were also slightly varied with head space temperature inside the dryer at Trial 1, Trial 2, Trial 3, Trial 4, Trial 5, and Trial 6 (Figure 2a, b, c, d, e, f). Sometimes, the ambient air temperature was higher than the paddy space temperatures and vise- versa. As for example, at day 1 of trial 1 (Figure 2a), it was found that almost all the points the paddy space temperature was lower than the ambient air temperature and even the difference was negative though solar radiation was higher around 700W m^{-2} at 12:00 pm to 1:30 pm. That might be occurred due to high moisture content of paddy (25.80%) at the beginning of drying operation. And thus, the moisture of the paddy mass was evaporated and the paddy space air might be moist than the ambient air temperature. However, the natural convection of air and lack of air flow direction, heated air did not pass properly through the paddy space at the beginning.



(a) Trial 1

(d) Trial 4

(b) Trial 2

(e) Trial 5

(c) Trial 3

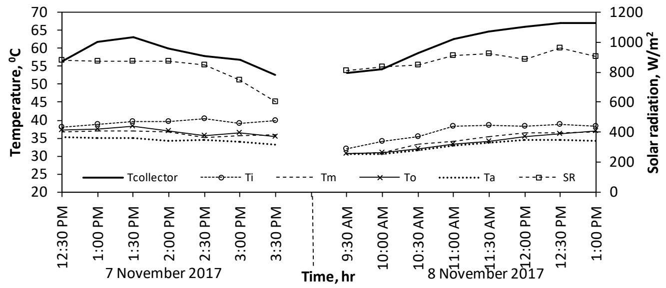
(f) Trial 6

(a) Trial 1, (b) Trial 2, (c) Trial 3 with paddy variety BRRI Dhan 50 and (d) Trial 4, (e) Trial 5 and (f) Trial 6 with paddy variety BRRI Dhan 29

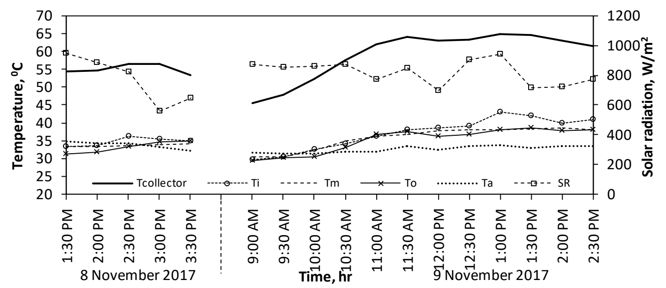
Figure 2 Effect of solar radiation on temperature distribution in and outside S4S solar grain dryer in *Boro* season at different trials

Note: Ti, Tm, and To average temperature inside the paddy space at inlet side, middle position and outlet side, respectively; $T_{collector}$ means head space air collector temperature; SR means solar radiation.

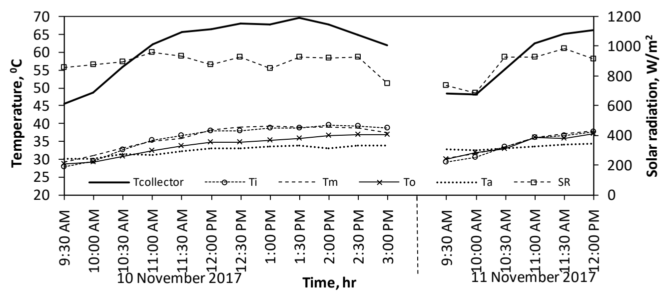
On the other hand, the difference of the paddy space temperature and ambient air temperature was given positive value with increase in time and solar radiation and reached at desired moisture content. The reason was that with increase in solar radiation, heat was trapped by the collector, was increased the temperature of air at the head space of the dryer and the heated air was passed through the paddy space by natural convection. For example, at day 3 of trial 3 (Figure 2c), it was observed that the difference of head space air temperature that means collector temperature of the dryer and ambient air temperature was found 21°C to 23°C higher at better solar radiation around 850 W m^{-2} at 1:30 pm to 2:30 pm during drying time. Then, the paddy space temperature heated up and showed higher temperature than ambient air temperature when moisture content of paddy was lower than initial. For example, at day 2 of trial 2 (Figure 2b), paddy space temperature showed higher than ambient air temperature at all the points at time 2:00 pm to 5:00 pm during the drying operation. It was also observed that at trial 6, the rate of solar radiation was changed rapidly and the ambient air temperature showed higher than the paddy space temperature at the first three days. At Trial 6, it was needed more time to dry the paddy, i.e. 29 hours within 6 days than the other trial with respect to solar radiation. The reason was that paddy was wetted and initial moisture content was higher (30%) than other trial and continuous rainfall was started at day 4 at 3:30 pm, thus created a gap to continue the trial.



(a) Trial 1



(b) Trial 2



(c) Trial 3

(a) Trial 1, (b) Trial 2 and (c) Trial 3 with paddy variety BINA Dhan 7 in *Aman* season

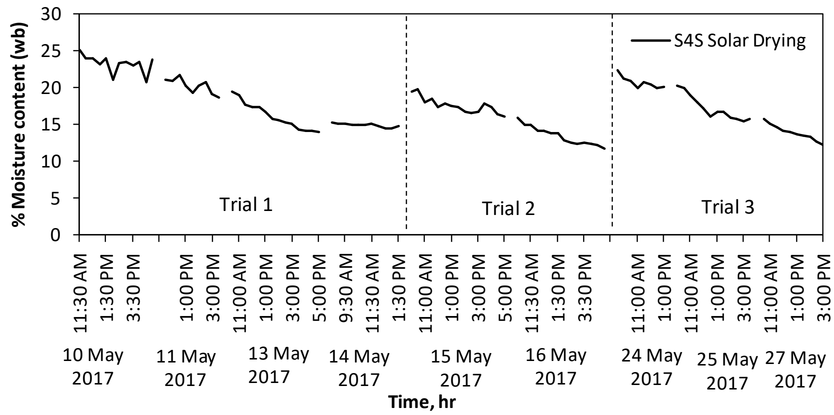
Figure 3 Effect of solar radiation on temperature distribution in and outside S4S solar grain dryer at different trials

Note: Ti, Tm, and To average temperature inside the paddy space at inlet side, middle position and outlet side, respectively; $T_{collector}$ means head space air collector temperature; SR means solar radiation.

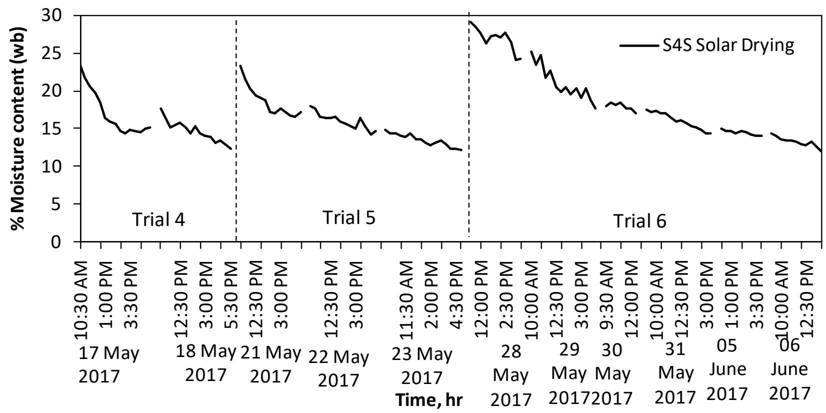
Effect of solar radiation on temperature distribution was found almost similar trends as *Boro* season in and outside the dryer in *Aman* season with BINA dhan7 as shown in Figure 3. However, it was also observed that the difference of paddy space temperature and the ambient air temperature was showed positive value almost all the points. In both seasons, it was evident that the grain space temperature of all points in all trials was less than 43°C whereas the maximum collector temperature was 61.5°C and 69.7°C in *Boro* and *Aman* seasons, respectively. The drying air temperature of 43°C is accepted as the safe upper limit of drying seeds without damage (IRRI, 2013). Therefore, the dryer would be suitable for drying paddy seed.

3.2 Variation of moisture content during drying operation in different seasons

In *Boro* season, the moisture content was decreased gradually in all the trials from initial moisture content and reached at the level of 12% with respect to time except Trial 1 (Figure 4a). The initial moisture content of Trial 1, Trial 2 and Trial 3 were 25.7%, 19% and 22.5%, respectively and required 21, 13.5 and 13.5 hours, respectively to reach the final moisture content of paddy seed. In case of Trial 1, the graph showed the same trend and the final moisture content was 14% because drying operation was stopped due to rainfall starting at 1:30 pm in day 4.



(a) BRRI Dhan 50 in *Boro* season



(b) BRRI Dhan 29 in *Boro* season

Figure 4 Average moisture content during drying operation with different time

In Figure 4b, the initial moisture content of Trial 4, Trial 5 and Trial 6 were 23.5%, 23.2% and 29.1% and drying time were 14, 20 and 29 hours, respectively to reach the desired moisture content of paddy seed. It was also observed that, at Trial 6, drying time was higher than the other trials and needed 6 days to reach the final moisture content at 12%. The reason was that paddy was wet and the initial moisture content was much higher than the other trials. However, the drying operation was hampered because of heavy rainfall and unpredictable weather condition.

Variation of moisture content of paddy seeds in the S4S solar grain dryer during drying operation was observed in *Aman* season (Figure 5). The moisture content paddy seed inside the dryer was reduced gradually from initial moisture content to a final moisture content at 11% with respect to time at Trial 1, Trial 2 and Trial 3. Time required to reduce moisture content from 15.47%, 15.53% and 15.87% MC (wb) to the final moisture content (i.e. around 11% MC) were 6.50, 7.50 and 8.00 hours for Trial 1, Trial 2 and Trial 3, respectively. Les drying time was required because lower initial moisture content. The farmers do the initial drying of paddy on the field just after harvesting in Aman season. The moisture content of paddy inside three positions of the dryer was almost same at Trial 1. Thus created uniform dried paddy seed. Trial 2 and Trial 3 followed the same trend. In case of open sun drying (Figure 5), it was needed more time to reduce initial moisture content from 15.47% to a value of 11% for Trial 1. The moisture content reduction was not uniform thus created non-uniform dried paddy. The foreign particles were mixed during drying paddy seed in open sun drying.

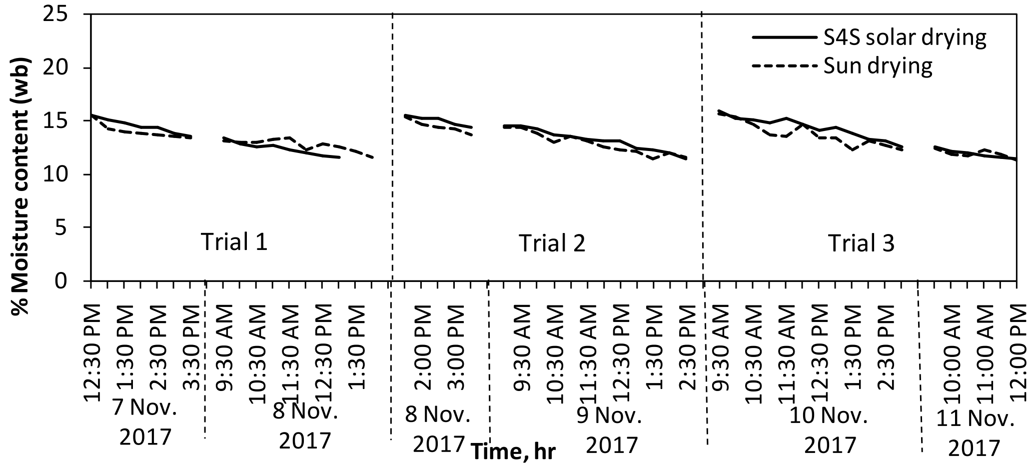


Figure 5 Variation of moisture contents during drying operation with S4S solar dryer and Open sun drying with paddy variety BINA Dhan 7 in *Aman* season

3.3 Technical performance of S4S solar grain dryer

Technical performance of S4S solar grain dryer is shown in Table 1. Drying operation was stopped at 12% moisture content for all trials except Trial 1 which was stopped at 14% moisture content due to rainfall in *Boro* season and in *Aman* season drying operation stopped at 11% moisture content for all the trials. Drying time was varied due to weather condition and initial moisture content. There was no clear evident of varietal effects on drying time of paddy. At trial 6, the drying time required to reach the final moisture content was higher than all the trials in *Boro* season. The reason might be the high initial moisture content of paddy and the weather condition.

Table 1 Technical performance of S4S solar grain dryer

Season	Trial	Initial MC, %	Final MC, %	Initial weight of paddy, kg	Final weight of paddy, kg	Drying time, hr	Moisture removed, kg	Drying Rate, % MC hr^{-1}	Efficiency, %	Drying loss, %	Average loss, %
Boro											
	1	25.80	13.38	46.00	39.20	21.00	6.60	0.59	56.45	0.52	0.58
	2	19.40	11.40	46.00	41.70	13.50	4.15	0.59	38.08	0.35	
	3	23.30	12.00	46.00	39.77	13.50	5.91	0.84	49.52	0.81	
	4	23.76	12.68	55.00	47.82	14.00	6.98	0.79	54.30	0.42	
	5	23.34	11.94	55.00	47.50	20.00	7.12	0.57	43.28	0.79	
	6	30.00	11.00	55.00	43.00	29.00	11.74	0.66	47.75	0.60	
Aman											
	1	16.10	11.11	42.40	39.96	6.50	2.38	0.77	30.31	0.15	0.41
	2	16.12	10.90	42.40	39.50	7.50	2.48	0.70	29.13	1.04	
	3	16.00	11.00	42.40	40.00	8.00	2.38	0.63	23.56	0.04	
Sun drying	1	16.10	11.12	42.40	38.89	7.50	2.38	0.66		2.83	2.12
	2	16.12	11.11	42.40	38.88	7.50	2.39	0.67		2.82	
	3	16.00	11.35	42.40	39.90	8.00	2.22	0.58		0.69	

The maximum drying rate was found at Trial 3 in *Boro* season. The reason was that due to high solar radiation intensity, it was needed less time (13.5 hour) to reach the desired moisture content of paddy seed. The average drying loss measured in S4S solar grain dryer in *Boro* and *Aman* season was 0.58% and 0.41%, respectively, which were 72% to 80% lower than the open sun drying method (2.12%). The reason was that seeds were protected from birds, flies, dust and rains due to closed system during drying operation. Alam et al. (2016) found drying loss 2.41% to 3.95% in traditional open sun drying method. That means at least 1.6% loss can be saved by using S4S solar grain dryer at the time of drying paddy seeds. However, because of closed system of the dryer, there is no chance of adding/mixing impurities as well as soaking with rain water during drying using S4S dryer which is the case for open sun drying method.

Moreover, stirring is not needed in drying seed with S4S dryer.

3.4 Seed quality test

Paddy seed quality test of paddy seed were determined in terms of germination rate and vigor index of seed for all the Trials during *Boro* and *Aman* seasons (Table 2). Seed germination depended on water availability and temperature. The higher the germination rate and vigor index indicated better quality of seeds. In *Aman* season the germination rate was found lower (82% to 85%) than the *Boro* season, the reason might be due to cold weather, the ambient temperature was low and seeds did not get appropriate temperature for germinate and also might be over dried paddy seeds because initial paddy drying is occurred in open sun drying at the field in *Aman* season. From the Table 2, it was also noticed that the germination rate and vigor index of S4S solar grain dryer dried paddy seeds were higher than open sun dried paddy seeds in *Aman* season. The reason might be the non-uniform dried paddy seeds in open sun drying, thus creates more dead seeds. As a result, low germination and vigor index was found in open sun dried paddy seeds. From the above discussion, it might be said that quality of S4S dried paddy seed was better than sun drying.

Table 2 Seed quality test of paddy seeds

Season	Trial	Number of seeds germinated	Dead seeds	Germination rate, %	Seedling length,cm	Vigor index
Boro						
	1	96	4	96	22	2112
	2	92	8	92	21	1932
	3	93	7	93	24	2232
	4	97	3	97	20	1940
	5	91	9	91	18	1638
	6	93	7	93	21	1953
Aman						
	1	83	17	83	25	2067
	2	82	18	82	22	1811
	3	85	15	85	24	2032
Sun drying	1	80	20	80	25	1973
	2	79	21	79	22	1738
	3	80	20	80	22	1753

4 Conclusions

The temperatures inside the S4S solar grain dryer at all the points of inlet, middle and outlet locations were fluctuated within a narrow band. Temperature difference in and outside the dryer was varied depending on solar radiation, time of the day and seasons. Drying time was much higher in *Boro* season than the *Aman* season. Initial moisture content of *Boro* paddy was higher than the *Aman* paddy. However, the rain and cloudy weather hampered drying by S4S dryer in *Boro* season which was not the case in *Aman* paddy. The S4S dryer could save drying loss 1.6%. The germination rate and vigor index in S4S solar grain dryer dried paddy seed were satisfactory compared to sun drying. In terms of drying loss, germination rate and vigor index, S4S solar grain dryer would be better option for drying paddy seed than traditional sun drying method. However, financial performance analysis of S4S paddy seed dryer is recommended for future study.

Acknowledgement

This research was performed as part of PHLIL project ‘‘USAID Post-Harvest Loss Reduction Innovation Lab - Bangladesh Component’’ funded by the USAID, USA and ADM Institute for the Prevention of Post Harvest Loss, University of Illinrois, USA (Grant Number: UReRA 2015-05296-01-00)

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Nomenclature

BAU	=	Bangladesh Agricultural University
FPM	=	Farm Power and Machinery
BADC	=	Bangladesh Agricultural Development Corporation
S4S	=	Science for Society
%	=	Percent
et al.	=	And others
Figure	=	Figure
g	=	Gram
kg	=	Kilogram
m	=	Meter
cm	=	Centimeter
$m\ s^{-1}$	=	Meter per second
m^2	=	Square meter
$W\ m^{-2}$	=	Watt per square meter
KW	=	Kilowatt
MJ	=	Mega joule
s	=	Second
hr	=	Hour
MC	=	Moisture content
^oC	=	Degree Celsius
wb	=	Wet basis
Nov.	=	November
i.e.	=	That is